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Method in Science Teaching¹

BY JOHN DEWEY, Columbia University.

Method means a way to a result, a means to an end, a path to a goal. Method therefore varies with the end to be reached. Without a clear notion of the end, we cannot proceed intelligently upon the journey toward it. When we try to state the end of science teachings we are, however, likely to find ourselves involved in such vague generalities that all might use the same words and yet differ radically about actual method of procedure. It is therefore only to make clear my own point of approach and not to foreclose discussion that I say that the end of science teaching is to make us aware what constitutes the most effective use of mind, of intelligence. To give us a working sense of the real nature of knowledge, of sound knowledge as distinct from mere guess work, opinion, dogmatic belief or whatever. Obviously science is not only knowledge, but it is knowledge at its best, knowledge in its tested and surest form. Educationally then what differentiates its value from that of other knowledge is precisely this superior quality. Unless it is so taught that students acquire a realizing sense of what gives it its superiority, something is lost. If we ask how this superior type of knowledge came into existence we find that men have been working their minds, more or less effectively for many thousand years, and that for a very long time it was less rather than more effectively. But the most efficient ways of using or working intelligence have gradually been selected and cultivated. And science as a personal power and resource is an equipment of all those found most successful, most

¹ Address before the Science Section of the N. E. A., in New York, July, 1916.

effective. A man may have a good deal of cultivation, a good deal of information, correct information at that, about things, but if he has never made a first hand acquaintance at some point with scientific ways of dealing with a subject matter, he has no sure way of telling the difference between all wool knowledge and shoddy goods. He has no sure way of knowing when he is using his mental powers most capable and fruitfully. An ability to detect the genuine in our beliefs and ideas, the ability to control one's mind to its own best working is a very precious thing. Hence the rightful place of science in education is a fundamental one, and it is correspondingly important to see to it that methods of teaching are such as to fulfill its true purpose.

When we pass from this generality, it seems to me that the first need is to discriminate certain stages in the educational development of science. The first stage belongs of necessity to the elementary school, for I do not think that any amount of pains and ability in the high school can make up for a wrong start or even a failure to get the right start in the grades. This is contrary in appearance to a common assertion of secondary teachers that they would prefer that their pupils came to them without any science instruction at all—which is paralleled by a similar statement on the part of the college teachers. I think the inconsistency is only in appearance. The remark is really proof of the necessity of a right start. I do not believe that the problem of successful science will be met until teachers in college and high school exchange experience with those in the elementary school, and both take a mutual interest in one another's work.

At this stage, the purpose should be to give a first hand acquaintance with a fair area of natural facts of such a kind as to arouse interest in the discovery of causes, dynamic processes, operating forces. I would emphasize the clause regarding "of such a kind." I think the chief defect, upon the whole, in our present elementary nature study is that while it may arouse a certain interest in observation and accumulate a certain store of information, it is too static, and hence too miscellaneous. By static I mean that observation is directed in some active process. No amount of information of this sort can supply even a background for science. Space, however, forbids my dwelling upon this point, and its underlying point can perhaps be brought out by reference to something which lies within the high school program, namely,

so called general science. Like the nature study movement the tendency to general science courses is animated by a praiseworthy desire to get away from the specialized technicalities of a highly matured science. I will not say that these reduce themselves for the average beginning student to mere acquisition of a vocabulary, though there is danger of this. But except with the few this science of the accomplished specialist remains, even when fairly well understood, just an isolated thing, a thing of a world super-added to the everyday world, when it ought to be an enlightening and an intellectual control of the everyday world.

As an attempt to get back nearer to the world in which the pupil lives, and away from a world which exists only for the scientist, the general science tendency has, as I have just said, its justification. But I have an impression that in practice it may mean two quite different things. It may take its departure from sciences which are already differentiated, and simply pick out pieces from them, some from physics, some from chemistry, some from physiography, some from botany, etc., and out of this varied selection form something to serve as an introduction to sciences in a more specialized form. Now this method I believe to be of the static type after all. It gives scope for variety and adaptation, and will work with the right teacher. But urged as a general movement, I believe it retains the essential mistake of any method which begins with scientific knowledge in its already made form, while in addition it lends itself very easily to scrappy and superficial work, and even to a distaste for the continued and serious thinking necessary to a real mastery of science.

General science may, however, have another meaning. It may mean that a person who is himself an expert in scientific knowledge, forgets for the time being the conventional divisions of the sciences, and puts himself at the standpoint of pupil's experience of natural forces together with their ordinary useful applications. He does not however forget the scientific possibilities of these experiences, nor does he forget that there is an order of relative importance in scientific principles—that is to say, that some are more fundamental, some necessary in order to understand others, and thus more fruitful and ramifying.

While then he may take his subject-matter from any of the ordinary and more familiar materials of daily life, he does not allow that material in its obvious and superficial form to dictate

to him the nature of the subsequent study. It may be varnish or cleansers, or bleachers, or a gasoline engine. But he never for a moment allows in his educational planning that thing to become the end of study; when he does, we have simply the wrong kind of elementary nature study over again. To him, as a teacher, the material is simply a means, a tool, a road. It is a way of getting at some process of nature's activity which is widely exemplified in other phenomena and which when grasped will make them more significant and more intelligible. While the student's attention may remain, so far as his conscious interest is concerned, upon the phenomena directly in front of him, it is the teacher's business to see that he gets below the surface to the perception of whatever is scientifically in the experience. This need not be labelled a principle or law—in fact, if it is so labelled at first, the name principle or law will be merely a label. But if further material is selected so that what the pupil got hold of before serves as a means of intellectual approach and understanding, it becomes a principle or law for him: a law of his own thinking and inquiries, a standpoint from which he surveys facts and attempts to reduce them to order.

This same method of procedure means of course that choice is made in fixing the kind of familiar material with which one sets out. The interests and occupations of the environment will play a part. A farming environment would tend to provide one point of departure, a district in which electric apparatus was made another, a railway center a third, and so on. But in each case, there will always be room for choice between material which tends to begin and end in itself and that from which something may be easily extracted which will give pupils a momentum to other things.

My point may perhaps be stated by saying that the right course lies between two erroneous courses. One method is the scrappy one of picking up isolated materials just because they happen to be familiar objects within the pupil's experience, and of merely extending and deepening the range of the pupil's familiarity, and then passing on to something else. No amount of this will make an introduction to science, to say nothing of science, for an introduction leads or draws into a subject, while this method never, save by accident, gets the pupil within the range of problems and explanatory methods of science. The other erroneous course is taken when the teacher's imagination is so limited that he can-

not conceive of science existing except in the definitely segregated areas, concepts and terms which are found in books under the heads of physics, chemistry, etc., and who is thus restricted to moving within these boundaries. Such a person forgets that there is no material in existence which is physical or chemical or botanical, but that a certain ordinary subject-matter *becomes* physical or chemical or botanical when certain questions are raised, and when it is subjected to certain modes of inquiry. What is desired of the pupil is that starting from the ordinary unclassified material of experience he shall acquire command of the points of view, the ideas and methods, which *make* it physical or chemical or whatever.

I return to what I said at first about the dynamic point of view as the really scientific one, or the understanding of *process* as the heart of the scientific attitude. What are called physics and chemistry deal in effect with the lawful energies which bring about changes. To master their method means to be able to see any observed fact, no matter how seemingly fixed and stubborn, as a change, as a part of larger process or on going. In this sense, they are central (along with mathematics which alone deals with the fixed, the formal and structural side of the fact) in all scientific understanding. There is a sound instinct in the tendency to insist upon them as the heart of the secondary course in science and to look with jealousy upon whatever narrows their sphere of influence. But it does not follow that the material which is found in the text which segregates certain considerations under the heads of physics or chemistry is the material to begin with. That is the fallacy against which I have been arguing. Plant and animal life, the operations of machines and the familiar appliances and processes of industrial life, are much more likely to furnish actual starting material. What the principle calls for is that the pupil shall be *led* in his study of plant and animal life, of machine and its operations, to the basic operations which enables him to *understand* what is before him—to be led inevitably to physical and chemical principles. Nothing is more unfortunate for education than the usual separation between the sciences of life and the physical sciences. Living phenomena are natural and interesting material from which to set out, especially in all rural environments. But they are educationally significant in the degree in which they are used to procure an insight into just those principles which are not plants and animals, but which, when they

are formulated by themselves, constitute physics and chemistry. It is the failure to carry nature study on to this insight which is responsible for its pedagogically unsatisfactory character: and the movement toward general science will repeat the same unless it keeps the goal of physical and chemical principle steadily in view.

An extension of the method I have spoken of should in my judgment constitute the bulk of the secondary course in science, which ideally should be continuous thruout the four years—or the six. We must remember that altho in school we are always treating pupils as embryonic scientists who somehow get interrupted and cut off before they get very far, the great mass of the pupils are never going to be scientific specialists. The value of science for them resides in the added meaning it gives to the usual occurrences of their everyday surroundings and occupations. None the less, we want a high school which will tend to attract those who have a distinct calling for specialized inquiry, and one which prepares them to enter upon it. I can only express my belief that there are many more such in the pupil population than we succeed at present in selecting and carrying on, and that I believe this is largely because we follow to so great an extent the method of feeding them all from the start as if they were full fledged minute specialists. As a result large numbers who might otherwise be drawn later into the paths of scientific inquiry now get shunted off into the more concrete and appealing paths of engineering, industrial invention and application—simply because they have been repelled by a premature diet of abstract scientific propositions, lacking in meaning to them because abstracted from familiar facts of experience.

I believe there are scores if not hundreds of boys, for example, who now go from technical courses of physics into automobile factories and the like, who, if they had begun with the automobile under a teacher who realized its scientific possibilities, might have gone on into abstract physics.

I can sum up by saying that it seems to me that our present methods too largely put the cart before the horse; and that when we become aware of this mistake we are all too likely to cut the horse entirely loose from the cart, and let him browse around at random in the pastures without getting anywhere. What we need it to hitch the horse of concrete experience with daily occupation and surroundings to a cart loaded with specialized scientific know-

ledge. It is not the business of high school science to pack the cart full—that will come later. It is its business to make such a good job of the hitching that every pupil who comes under its influence will always find in himself a tendency to turn his crude experiences over into a more scientific form, and to translate the bare science he reads and hears back into the terms of his daily life. When we do this, we shall find, I am confident, the crop of scientific specialists increased, not diminished, while we shall have a citizenship of men and women really intelligent in judging the affairs of life.

The University and Business'

BY A. D. LITTLE, Boston.

It is a platitude to say before an audience like this that there is a great need at the present time on the part of bankers, capitalists, men of affairs, and directors of industry, and in no less degree on the part of superintendents, foremen, work people and the public generally, for a better appreciation of the part which science plays in furthering industrial development, increasing the efficiency of production, raising the scale of wages, and insuring preparedness, whether for peace or war.

BUSINESS MEN IGNORANT OF SCIENTIFIC POINT OF VIEW

This need arises from the fact that men of affairs, and especially financiers, have seldom received a scientific training or acquired a working knowledge of the scientific method or fully understood the scientific point of view. They consequently often fail to realize the intrinsic merit of industrial propositions which are based essentially upon new application of applied science, and to gauge with accuracy their chances of success.

PREVALENT IGNORANCE OF ORDINARY SCIENTIFIC PHENOMENA

Those of us who have received the benefit of any sort of scientific training are constantly amazed at the ignorance of cultivated men and women, business men and work people, regarding the simplest phenomena by which they are surrounded. To a deplorably large proportion of the community the striking of a match, the lighting of a fire, the freezing of water, the falling of snow, the sending of

¹ Extract from address before the New York Section of the Society of Chemical Industry, December 10, 1915.

a telegram or a talk by telephone, the operation of a steam engine, or the turning on of an electric light involves mysteries as far beyond their range of thought as the cause of gravitation or the rotation of the nebulae.

Since business involves at every point contact with natural phenomena and since the proper understanding of these phenomena or at least some realization of what underlies them, often determines the measure of success attained in business, the university might well establish a compulsory elementary course in *general science*. This should be designed to give the student at least a rudimentary knowledge of the field covered by the different sciences, the relation of the field covered by the different sciences, the relation of their subject matter to natural phenomena in the affairs of every-day life and those of business, the interdependence of the sciences, and, above all, a clear idea of the scientific method. Such a course could not fail to prove an immense stimulus to any intelligent mind. It would open out new horizons for thought and put an altogether different and more interesting aspect on the world in which we live and in which we must do business.

Connecticut System of Elementary School Science

BY LOTHROP D. HIGGINS, Head of Science Department,
State Normal School, Danbury, Connecticut.

Fifty-seven science cabinets were bought by towns in Connecticut during the past year for use in the elementary schools. Twenty-five more were in use, having been loaned by the State Board of Education. These cabinets contain material for demonstration exercises in physical science, with a booklet of information and suggestions for experiments and lesson procedure; they are followed by a series of occasional letters intended to direct and encourage the teachers who are doing the work. The state has made and loaned these boxes of apparatus for some years, but the increasing demand made it seem wise to attempt their sale. In a few cases the town bought more than one cabinet, but the whole number of towns in the state that are using them is over fifty. The fact of these boxes having been bought by the town after

previous opportunity to use them free of expense would seem to indicate that somebody thought the work worth doing.

This is the present status of a several years' effort to establish some teaching of everyday science in the elementary schools. The purpose is not to have some recognized branches of science taught in the lower schools, but rather to try and overcome certain defects in the results of common school training. The great majority of people take very little interest in any of the wonders about us that do not immediately concern them, and have little capacity for independent thinking when new situations require it. And this in an age which is more than ever being enriched with what man has drawn from his surroundings by his own study and invention. The primary object of this work in natural science is to give pupils an intelligent curiosity about the useful and interesting things around them, and make them do more real thinking.

The first, and we might almost say the one, great need is for teachers who can do it. The teacher who has the spirit and the ability to do this work can do it anyway—whether or not she has any "apparatus" or can get the time set apart on her program. Many a good teacher, at odd times and in the course of other subjects, has given some of her pupils the great inspiration of their lives. But teachers are shy at starting this work, even though they know its results to be felt in the general good of the school, because they feel their lack of knowledge. It is hard to meet the questions of earnest pupils, and it is hard to realize that she who is herself a student of the same things with them makes the best teacher. Almost any good elementary teacher has knowledge enough to serve as a foundation for this work, if she only knew how to go about it and had confidence. The confidence and the realization of its worth will come as she gains experience, as will also the better technique and the increase of information. But it is necessary at the beginning to help each teacher along all these lines as much as possible without making her dependent on that help. Hence the cabinet of apparatus, the booklet of information and suggested procedure, and the occasional letters that follow.

The work as laid down in the booklet is based upon physics, mostly such matters as would fall under physical forces, effects upon liquids and gases and heat. Ninety-six experiments are described, and their relation to the lessons is indicated by questions, to which answers are given also. Principles and numerous applications are given. The cabinet contains the material necessary for

all the experiments. The box complete with the booklet is sent by mail to any school in Connecticut for \$7.50; this is as near the exact cost as can be figured, excluding the labor of making some of the pieces and assembling the material. Provision is made for replacing lost or broken pieces at cost. The whole matter of making and caring for the boxes and apparatus is handled at the Danbury Normal School, with the financial help of the State Board of Education.

The experiments are simple demonstrations of familiar phenomena, each of which serves as a basis for discussion of kindred things which the pupils have noticed, with a view to finding the general truth that is common to them all. Then the pupils are encouraged to look for other cases where this same truth applies, and further lessons are based on the results of such inquiry. This in brief is the general method, though occasional lessons are conducted on other lines. It is by no means important that the work should be based on physics. It was necessary to place some information, material and definite directions at the teachers' command, and this could be done more economically with these than with any other subjects of equal breadth and value. But the teachers are encouraged to digress from this prescribed outline and use other material whenever they feel they can do it profitably. The great thing is to get both teacher and pupils working together in the spirit of real students, and when this spirit prevails the question of what subjects are used may well be settled by circumstances.

But it takes time and frequent repetition to implant ideas as working principles in others. The teachers are given some aids whereby they can do certain definite work, and this should help to start them. But the matter cannot be taken up in rural teachers' meetings often enough to be effective, and supervisors have many other matters that demand attention. So we are trying the plan of following up each teacher with a series of "letters", about a month apart, in which the methods and purposes of the work are discussed. These letters go to each teacher who has a cabinet, and to her supervisor. They are planned with a view to first helping the teacher with her immediate problem, and finally working around to where the significance of the work will be apparent—by which time it is hoped also that she will want to go ahead with subjects of her own choice, in which she has become interested. The letters are printed and there is no charge for them.

Most of these boxes have gone to the smaller towns, where the work is done chiefly in one-room rural schools. A few have gone to city schools, and some other Connecticut cities are doing similar work in science. In Stamford it is done in the upper grades as departmental work by a teacher who is capable and willing. In Norwalk it is carried on by room teachers under close supervision of the high school science department. In New Haven and Danbury it is in charge of the normal schools.

In the one-room rural schools the work is usually done with all classes from about the fourth stage up, reciting together. In the city schools it is done chiefly in the seventh and eighth grades, though there is no reason why it cannot be profitably used in lower grades, as it sometimes is. Two twenty-minute periods a week are usually allowed, though in the two upper grades the periods are sometimes longer. The work indicated in the booklet could be extended over two years by some teachers, while others might go through it in one; in Danbury it covers three half-years, with kindred work from other subjects in alternate half-years.

But this is pioneer effort at a thing which holds far more worth than these attempts alone are going to bring out. It is a shame and a real loss to our civilization that as a people we know and care so little about the interesting and important knowledge that is so close at hand. These efforts may fail and the subject die out from our schools, but the time will come when thought-and-interest lessons based on natural science will have their established place in the common schools of America.

Project Teaching¹

PROF. C. R. MANN, of the Carnegie Foundation.

There seems to be a general impression that project teaching and general science courses are suitable only for grammar schools and the early years of the high school. Even the high school teachers themselves speak of the need of a regular or formally organized science course for the third and fourth years. So far as I am aware, no one has yet proposed general science courses for the colleges and universities. Yet the work of all the research men in

¹ Abstract of address delivered at a General Science Conference at Salem, Mass.

the country and the work of the advanced students in science is always carried on by the project method and is successful in proportion as the project is really the student's own.

The same is true in the engineering colleges. Among the professional engineers there is a very marked demand for what they call "general engineering science". It is pointed out that a man who graduates from a civil engineering course frequently makes his success in life in mechanical engineering or vice versa. It is also pointed out that all engineering problems are essentially projects and that many of them involve a very wide knowledge of the different fields of science. To be a successful engineer thus involves having the ability to tackle and solve projects efficiently and this ability is acquired like every other ability by practice and training in doing. It therefore follows that the most efficient training of engineers is likely to be secured in those schools in which the project method of instruction is used most freely.

It is difficult for teachers to get started with the project method because it is so different from the one by which we were ourselves taught. Professor Dewey has given us a formula which is very valuable if it is used intelligently and not followed too blindly. This formula may be stated in this way: The old system of instruction had for its aim, first the development of technique on the ground that this technique might at some future time be of use to the student. The project method teaches technique only in response to the personal need felt by the student himself. The formulae thus will run:

Old Method: 1-Technique 2——?

New Method: 1-Need 2-Technique.

Projects

BY J. C. MOORE, High School, Bridgeport, Connecticut.

Much of the science teaching of the past reminds me of a remark made by a young Chinese student of my acquaintance. After seeing one of his first games of American baseball, in which his school team was badly beaten, due to a number of wild throws, he was called upon to give his version of the defeat. "Well", he said smiling, "our team have only one fault, they throw the ball where there isn't anybody." Much of our science teaching is thrown where there isn't anybody. In other words, it doesn't reach its

goal, largely because the subject matter and the method are not vitally connected with the needs and interests of individual students.

In teaching science by projects we try to start with the live curiosity of the boy or girl as based in the solution of their needs. Professor Dewey in his book, 'How We Think', has given us the key for good teaching, and his outline of the process furnishes the method for handling future projects.

No teacher can tell just how a given project may arise, in just what form of question the need may be expressed, but the need will usually express itself spontaneously. The same project may arise in a dozen different forms, but when once expressed, leads into many different fields where the boundary fences of subject matter have long since ceased to exist. Today a girl may seek, "Why rain water makes better suds than tap water?" or "Why a crust forms inside the teakettle?", a boy may ask, "Why do boilers explode?", or "Why is Great Salt Lake so salt?" In each event the project of Hard Water is started, and will lead us through the various connecting links, gathering much desired information on the way, until we feel the satisfaction of solution. It will touch several subjects, it may take one or several periods, it will be vital, if not, it ceases to be a project for us.

The student usually sees only the first term of the process, need—technique—future needs, though he is constantly working toward the last term. Only through solving present needs can future needs be met, and the skillful teacher will study the last, as the student studies the first term. Through careful guidance of the project, by suggested lists of readings, by proposed experiments, by his own enthusiasm, the teacher can do much to strengthen the project method of attack.

The story of the student in manual training class, who enthusiastically entered upon the work of preparing garden-pegs for the spring planting, only to feel disgust at being kept for days at squaring, planing and sandpapering the part underground, illustrates the feelings of many present day students. Work done because it is vitally interesting to the individual and meets his needs, is of more permanent value than work done merely to meet the pleasure of a teacher.

Our work will be greatly aided by having the possibilities of a project well in hand, not that it may all be covered by each suc-

ceeding class, but as a kind of guide board leading to enchanted lands of investigation. Such a series of projects as the one here given in brief, can be listed on library cards with reading references listed on the back, and will grow in value with succeeding years.

HARD WATER

Scum when soap dissolves in water?—Bathtub.

Soap dissolves better in rain water than spring water.

Used to catch it in country.

Too much dirt and gas in city. CO_2 , SO_2 .

Rain water may be acid.

Even destroy architectural detail—Pittsburgh.

Cost to city—Rust—Cleaning buildings and windows.

Ground water.

Decaying vegetable acids.

Carbonic acid—Saratoga.

Dissolves rocks—limestone—Na, Ca, Mg, CO_3 , SO_4 , Cl.

Demonstration. CaCO_3 by carbon dioxide in lime water.

dissolve by excess of carbon dioxide.

Limestone caves. Kentucky—Mammoth Cave.

Stalactites, stalagmites from saturated solution.

Natural bridges.

Mineral springs, geyser deposits, Yellowstone Park.

Travertine of Italy.

Soil leaching—Mississippi deposits.

Sea water—Dead Sea—Great Salt Lake.

Minerals reappear in teakettle— CaCO_3 .

Boiler scale—cause of explosion.

Temporary hard water—calcium acid carbonate.

Effect of boiling.

Permanent hard water.

Calcium sulphate, less soluble in hot water.

Softened by soda.

How soap reacts with hard water.

Calcium soap.

Soap softens hard water.

Cost of softening by soda.

Relation of General Science to Later Courses in Physics and Chemistry¹

By LEWIS ELHUFF, A. M., George Westinghouse High School,
Pittsburgh, Pa.

This subject might suggest that I am attempting to assume the role of a prophet who is able to determine the nature of Physics and Chemistry as they will be taught in the future. But since the topic was assigned to me rather than of my own choice, there is some evidence that there are others who are conscious of the prophetic phase in all teaching, for teaching is training both for the present and the future. The one who understands the present well, will be very apt to choose wisely for the future. Then so far as we are teachers, we are also prophets. This places us all in the same class and I am no different from you in that respect.

Approaching this subject from the standpoint of the teacher, I would like to divide all teachers into two groups. These two groups are suggested by the attitude which teachers take with respect to what is commonly known as "General Science".

The first group consists of those teachers who teach a subject or develop a subject from the standpoint of the subject itself and make the student conform to the subject matter which the teacher thinks makes an ideal course because of the worth and beauty of the subject matter itself rather than the usefulness of the subject matter to the student pursuing it. This group of teachers want students to be purposefully prepared for the courses which they teach. (Under our present system of class grouping of students, it is a great advantage to have the students grouped according to the previous training. An advantage to whom? The teacher? No. It is an advantage to the learners, because under proper classification they will get more training during a given amount of time.)

The Physics and Chemistry teachers of this first group expect their students to have been trained or drilled in some of the fundamentals of these subjects and even to know how to perform experiments and write up notes in the form in which this group of teachers want them. Just as though learning to do experiments and writing laboratory note books were a business in itself. So much

¹ Address before the Chemistry Section of the N. E. A., at New York, 1916.

of our laboratory work is so formal that students are hindered rather than aided by it in securing useful knowledge and training. For a laboratory exercise, a proposition should be set and then let the student use his own originality and inventiveness to attain the desired end. The teacher by observation discovering the students difficulties, may lead him forward by suggestions or suggestive questions if it seems necessary for the progress of the student. Here I would like to suggest that the grandest laboratory of any High School, is the community in which that High School is located. To use this laboratory requires a different method than that used in most laboratories and a different attitude on the part of the teacher towards his subjects and his learners.

This brings us to the second group of teachers, namely, those who teach from the standpoint of the student and make the subject fit the student so that it will give him useful training for the present and future. This attitude requires the teacher to center the attention on the learner and study his characteristics and previous training and then adapt the subject matter to suit the circumstances which the teacher has discovered. (Here again I would like to suggest that learners who are grouped according to their previous training, will receive more training in a given amount of time than if they are not so grouped.)

This attitude on the part of a teacher requires the teacher not only to know the subjects being taught, but to know it so well that the subject can be adapted to the conditions in which the learner is found. The learner should be first in the mind of the teacher and the subject matter second. Keep in mind that living human beings are to be taught and not science subjects. Is this idea new? No. The great teachers, both religious and secular, who stand out in educational history had this conception of the relation of the subject matter to the learner.

On this basis or from this attitude I can make only one complaint or offer but one compliment to the teachers who send their students to me, namely, the students are not well trained or they are well trained considering the time the students spent with their teachers and the circumstances under which those teachers and students were working. This attitude also requires me to look upon a student as having received all the training that he can get from his former teachers who sent the student and who like most teachers are limited in their field of activity by an authority higher up.

On this basis to fail a student is to reclassify him for his benefit.

You have perhaps already discovered my attitude towards the relation of General Science to later courses in Physics and Chemistry. It is this—General Science has no more relation to future courses in Physics and Chemistry than it has to future courses in Botany, Zoology, Physiology, Physical Geography, Horticulture, or Bacteriology. General Science has a very vital relation to the present and the future of the student pursuing an acquaintance with himself and his environment the same as Physics, Chemistry, Zoology, etc. have a vital relation to the present and future of the student.

From this point of view I would like to go more into detail on this subject. What should be taught in a General Science course given during freshman year in High School considering the age and training of the student coming into our High Schools? The answer is, teach the student what he needs, what he can use. To do this the teacher must be a student of Sociology as well as Psychology and Pedagogy, and must study the social environment of the students in order to learn as much as possible about the students' experiences and the extent and nature of their observations and previous school training.

The previous school training that students have received will largely determine the method which can be used at the beginning of a General Science Course or any other course. A change in method means a change in formed habits of doing things. When students have formed the habit of parroting definitions of technical terms or quoting the text book or teacher, it is a difficult and slow process to get them to talk freely of their experiences which they have received outside of the text books or class room. Here it might be suggested that students who are taught to parrot definitions of technical terms used in Physics and Chemistry would be looked upon by some teachers as being well prepared to study Physics and Chemistry.

Of all the things which the General Science student should be introduced to, I would like to suggest the following.—1st. The student's own health. 2nd. The health of the family from which the student comes. 3rd. The health of the community in which the school is located; all from the hygienic standpoint. The health of the family and community are reached thru the health of the student.

Some of the things which relate to health and are common to all communities are—habits of the students in school, on the street, and in the home; the home, its heating, lighting, ventilation, and surroundings including plants and animals; sanitation in the home, cleanliness, nature and kinds of food consumed, apparatus and chemicals of the home; water supply and its purity and adaptation to the weather. These to be studied in detail to the extent of their usefulness to the students concerned.

These topics will not have the same characteristics in the environment of all schools and so it will be very necessary for the teachers to study local conditions in order that their teaching might be of service to the student body and community. These things are to be taught for the sole purpose of their usefulness to the students immediate needs and not to prepare a student for some future subject. The student who is prepared to live as completely as possible, will also be prepared to study any subject that is adapted to his age and degree of training.

How teach General Science to prepare students for Physics and Chemistry or any other subject? The answer is—Teach them in the same way as you would if they never intended to take up a more advanced subject, in other words, teach them how to live. That cannot be done by cramming and by parroting, but by drawing out and developing what capacities they have, that is, lead the student to discover himself or herself.

The general principle of all teaching is to proceed from the known to the related unknown. Every student has a quantity of experience which is sufficiently understood by him to be used as a foundation and also as a basis for helping the student to interpret new experiences and new facts. Every student also has a quantity of experience of which he understands a part. The part which he does not understand must be interpreted in the light of his experiences which are already clear and useful. The number of definite and distinct ideas in the students mind should be increased, the imagination developed, and the vocabulary of the student should be increased as fast as possible, without parroting. Excessive technical terms whose definitions are committed by rote, are a hindrance to progress. Terms which the student uses in his discussions are the only ones which are really understood.

The laboratory work for freshmen should be largely outside of the school room. It should be in the home to a maximum extent

for two reasons. 1st. The learners will see a practical value in the experiment and the experiment itself will be practice. 2nd. It draws the parents into educational relations with their children and the school. The habits of whole families can be changed by this method, thus producing a better environment in the home of the student. This will go a great way in preparing a student for future courses in Physics and Chemistry or any other subject.

No laboratory experiment should be conducted in the school unless an immediate application of the experience gained, is made to life outside of the school. Students, even seniors, easily fall into habits of thinking that experiments have an end in themselves and they fail to see the use of the principles involved except to perform experiments.

Students can easily consume all their time in learning the things for which they have immediate use. Virtually they learn only those things which they use. When a graduate starting in practical work, says that he had to learn it all over again, he means that he did not learn it while taking his course in school. By a constant effort to teach only that which students can use immediately and by teaching it thoroughly enough so that they can use it, there are some mental processes involved that are very important, namely, the power of selection, comparison, reason, and judgment. These powers being highly developed, the student will be able to take care of himself and acquire the necessary information when the occasion in his practical life requires it. Information about a thing may be important but practical information which enables the student to apply and use it, is more important.

There are a great many subjects taught in our schools in such a way that the general public can see no use for them except for those who are going to be teachers. Not that the subjects have no value but the form of the material as presented and the method of presentation prevents adaptation to the student's life unless the student makes practical application in spite of the methods and form of material; but such students are rare.

I would here like to suggest that you do not interpret what I call practical, in a narrow sense. Much of what some call cultural has a practical value in so far as it enables the student to understand his social and natural environment. Music, Art, and the related subjects which develop emotions and the aesthetic sense have a practical value in the daily life of the individual.

What I would like to impress upon you today is, to retain in General Science courses only the subject matter which can be adapted to the life of the student and let the same be done in Physics and Chemistry. Later courses in Physics and Chemistry will then contain only that which is of practical use to the student at the same time the courses are pursued. Later teachers of Physics and Chemistry will also have to see that their subjects are for the students use and not the students for the subject. The first year of Physics or Chemistry in High School can be confined to the Physics and Chemistry of the daily experiences of the student. This will mean the elimination of much that is now superficially taught in some schools and the addition of material with which the student is already partially familiar.

If later courses in Physics and Chemistry become what I have suggested, then how will General Science be related to them? The answer is at once apparent, namely, that General Science, when properly taught by adaptation to the life of the student, will have developed the student so that he will be able to think, judge, and apply information to new circumstances or conditions and have developed the habit of securing new information as is needed to meet a new condition. This quality in a student can be used in a home, on the street, in studies pursued in the future and in remunerative labor. A student possessing these properties will never fail to be benefited by a course in Physics and Chemistry if they are adapted to his capacity and immediate needs.

What then should be the aim of the teacher of General Science? Only this—adapt the subject matter to the student and teach him in such a way that he will be prepared to live now, and have no other thought of preparing him for any subject that is to follow except, the subject; “to live, to live completely, and to live abundantly.” Let this also be the aim of Physics and Chemistry teachers, and there will be unity, continuity and co-operation.

Lightning

By W. G. WHITMAN, State Normal School, Salem, Massachusetts.

Lightning, that awe inspiring natural phenomenon which compels the attention of child and adult alike, is the cause of about 800 deaths and of 1500 injuries sustained by the people of the United States in a single year. It also causes the destruction of many millions of dollars worth of property yearly.

Lightning is a subject worthy of study in general science classes both because it commands intense interest and because a wider knowledge of its behavior and the practice of known methods of protection against it, would prevent much of the loss of life and property. Lightning is a more vital subject in the country and small village than in the city. It is rare that lightning strikes in the large towns or cities. The isolated building or object is in greatest danger. The subject is of varying economic importance too in different states. Records show that lightning does more damage in Iowa than in any other state. Maryland, Wisconsin, New York, Ohio and Illinois follow in the amount of damage received from this source.

That the harmless spark obtained by rubbing a cat's fur in cold winter and the terrifying lightning of a hot summer day are closely related, belonging as they do in the same family of natural phenomena, has never been surmised by the average pupil. In fact many older people have not thought of them as related phenomena, even though Franklin proved their identity in 1752.

Benjamin Franklin while experimenting with electricity noticed certain resemblances between the sparks produced artificially and the natural lightning. Both flashes were instantaneous; gave intense light; followed a crooked path; produced noise; set combustible material on fire and killed animals. From observation of the similar behavior of the two, he was lead to a strong belief in their identity so he determined to perform some experiment which would prove their likeness or unlikeness. And on July 4, 1752 he sent a kite into the clouds during a thunder storm and succeeded in bringing electrical energy from the cloud through the kite string to a key at its lower end. This string and key were insulated from the earth by a silk cord. Franklin obtained sparks from the key just like those he had produced in his laboratory, thus did he

demonstrate to the world the fact that lightning is an electrical discharge.

The boy who shuffles his feet over the carpet and draws a spark from the water faucet or gas burner is a "dynamo" unawares; he generates electricity and discharges it at a pressure of thousands of volts. There is sufficient experience in the average child's life anywhere above the fifth grade to insure keen natural interest in a study of an electrical storm. When you attempt to catalog that experience and to record what that experience is, you may not be able to get a very large list of observed facts, but with time for reflection and the stimulus of suggestion, enough can be obtained to make a good experience background.

Some of the facts which may thus be gathered from a class are the following: Lightning is a characteristic accompaniment of a certain type of storm. This is called a thunder storm or an electrical storm. These storms are common after excessively hot days in summer but occasionally occur in winter. The storm is ushered in by the beautiful white cumulus clouds and strong wind, then follow dark clouds, rain, electrical flashes and thunder. The rain drops which fall during an electrical storm are very large; as a rule much larger than fall during an ordinary rain. People and animals are killed by lightning; trees and poles are broken and split; houses and barns are set on fire; even the ground is sometimes struck by lightning. When people are burned by lightning their skin is said to record photographic representations of nearby objects. Different "kinds" of lightning are recognized. During an electrical storm, the trolley car may be stopped and will not move until the intensity of the storm has passed. Lightning arresters are used to protect the telephone and lightning rods to protect buildings.

It is usually true that the air above the earth is positively electrified and that the earth differs in electrical pressure from all space around it by many—possibly 150,000—volts. It is not constant however, conditions are always changing and the electrical tension is variable. Such a difference of potential as this is not sufficient to produce lightning.

When clouds are rapidly formed by air currents rising into the air, enormous quantities of electricity are produced. We do not know exactly how it is produced. The latest theory, that of Dr. Simpson, explains the electrification as resulting from the splitting

of rain drops into smaller particles as they tend to fall through a rapidly rising current of air.¹ In some way clouds do become highly charged with electricity. Sometimes they are positively charged and sometimes negatively charged. When two clouds or a cloud and the earth are at sufficiently great difference of potential the resistance of the intervening air is overcome and a discharge takes place producing the common phenomenon of lightning. Sir Oliver Lodge calculated that a flash of lightning one mile long is probably due to a difference of potential of 5,000,000,000 volts, but it is generally thought now that this figure is too high. Trowbridge has found that a difference of potential of about 25,000 volts between battery terminals will give a $\frac{1}{2}$ -inch spark through air.

The duration of a flash of lightning is usually under 1-50,000 second and may be only 1-1,000,000 second. Because of persistence of vision we apparently see the flash for a longer time. According to calculations made by Lodge, a discharge from a cloud 10 yards square, fully charged, at a height of one mile, liberates 2,000 foot-tons of energy. This energy is enough to warm 40 grams of water to the boiling point and then change it to steam in a trifling part of a second. Such intense heat warms the particles of air to incandescence and is the cause of the flash seen. Heated air conducts electricity better than cold air, so at times other flashes will follow in the path of the first one before the air has become cold. These multiple or oscillating flashes may continue for 1-1,000 to 1-200 second but altogether they apparently make but one flash to the eye.

The discharge of this cloud, 10 yards square, gives enough energy, in 1-20,000 of a second, if properly directed, to hurl 1,000 barrels of flour 20 feet into the air. When this energy heats the air in the path of the lightning discharge it causes sudden expansion with explosive violence and when the expanded air cools and contracts a vacuum is formed, into which air rushes again with implosive force. When you blow up a rubber balloon to an excessive pressure, explosion results with a loud sound. When an incandescent bulb is broken, air rushes into the space and when it meets, it produces a loud sound from the implosion. These two cases illustrate the production of thunder. One part of a lightning flash may be a mile farther away from you than the nearer

¹ See page 11, Farmers' Bulletin, No. 367.

part. The thunder from the more distant part will reach you about 5 seconds later than that from the nearer part. Thus while a flash may be instantaneous, the thunder which you hear may be of considerable duration. Thunder from several flashes unite. Thunder may be reflected by one or more clouds. In these ways the rumblings, characteristic of thunder, are produced.

Objects standing on the surface of the earth become a part of it and are electrically charged the same as the earth. Standing above the earth's surface they form excellent discharge points since the air gap from them to the cloud is less than from the surrounding earth to the clouds, and furthermore, the electrical density or tension is greater at points, corners and angles than on surfaces. Whatever the object may be through which the discharge starts, it instantly becomes the conductor through which electricity passes either to or from a large area surrounding it. If an object only discharged an amount of electricity equal to that which it held before the discharge, there would be little danger or violence, but when it becomes the conductor to carry the electricity of a considerable portion of the earth about it, the large quantity of electricity passing in so brief an interval causes violence and damage.

A similar discharge of the earth occurs when an object on the earth is electrified by a near-by cloud by induction and a discharge passes between them. The discharges at the storm front are usually the most severe. After the first few discharges the air seems to become a better conductor and the lightning is less severe.

Any high object reaching above the earth carries the electrostatic field nearer to that of the cloud, thus increasing the possibility of an electrical discharge between them. The tremendous heat energy which is produced from the electrical discharge of a large cloud highly charged is sufficient to heat air particles to incandescence, to melt minerals and metals, to vaporize solids and liquids with explosive violence and to set fire to combustible matter. It is little wonder that trees are splintered and buildings set on fire when they make a path for the lightning to the earth—or from the earth—for it is believed that fully as many discharges are from the earth to the clouds as from the clouds to the earth.

Protection against lightning is needed on isolated buildings, tall chimneys, steeples, and flag poles. Protection is secured by use of a metal cage or series of rods with high points and the whole thor-

oughly grounded. The material must be of sufficient capacity to carry off large quantities of electricity and it must not corrode readily. Copper and galvanized iron are the two metals most commonly used for lightning rods. The lightning rods or conductors should not be insulated from the building because the object of the rods is to "drain" electricity from all objects about or apart of the building. Conductors ought not to be placed near or parallel to an inside pipe, because the discharge might jump through the wall to it, causing fire, or it might produce a powerful heating effect in it, resulting from induction. A safeguard against such a disaster is to connect the lightning rod system at the highest and at the lowest points with inside structural beams and water pipes. Sometimes gas pipes are connected but because of the inflammability of gas, many prefer not to connect them. All exterior metal work of the building, as gutters, railings, etc, either should be connected to the lightning rod at a level below their own or they should be grounded by a separate cable. The grounding of lightning rods is a very important matter. They are frequently connected to large copper plates which are buried in a mass of coke at a depth which is below the permanent water level of the earth.

The metal cage or rods should have a number of high points extending above the level of the building; and should have few joints and no sharp bends. Our commercial currents will follow good conductors around any amount of curving, but lightning will often jump off from a good conductor at a sharp bend, even though it must pass through a poorer conductor. Specifications for installing lightning rods and sizes of rods are furnished by the National Board of Fire Underwriters.

There are two ways in which lightning rods protects a house. First, they serve as conductors carrying the discharge harmlessly; second, they tend to discharge the earth slowly. Often such an amount of electricity escapes by this slow discharge that a lightning stroke is prevented or if not prevented, it is less severe. Occasionally a rodless house is struck, but the damage is much less than if the house had been unrodded. The idea that lightning rods draw lightning, and are a source of danger is unfounded even if the rods are poorly grounded. The majority of fires resulting when lightning strikes rodless buildings, occur when masses of metal, gutters, pipes, etc. are not connected to the lightning rods or are not grounded.

Lodge classifies lightning as *A flashes* and *B flashes*. The *A* flashes are less sudden and violent, and are what the Germans term "cold lightning." Lightning rods are effective protection against them. The *B* flashes are sudden and violent, and are what the Germans term "burning lightning." Lightning rods will not always safeguard against these flashes. Both the *A* and *B* flashes are fatal to man. *Ball lightning* is produced when the *B* flashes strike the ground. The *A* flashes are the more common. When a storm is at such a distance that flashes of light are seen but no thunder is heard, the flashes are termed *heat lightning*. The thunder may be refracted above the heads of the observer or it may be at such a distance that its intensity is so decreased as to become inaudible.

If a person forms a part of the conducting path of the discharge, he is likely to suffer and yet the stroke may not prove fatal.

The heart is the chief danger spot. It is not the voltage but the current which passes through the heart which is the important thing. Though with a given body resistance, an increased voltage causes an increased current to pass. It has never been determined with accuracy, just how much current can pass through the human body with safety. It doubtless varies with individuals. High voltage causes paralysis which may stop breathing, and even the heart's action. First aid in lightning stroke should be *artificial respiration*, the same as is used to restore a drowning person.

No danger results when a comparatively large current flows through the lower trunk alone, but as low a pressure as 65 volts has been known to prove fatal, when it passed through the thorax.

The resistance of the skin varies with its dryness, moisture, greasiness, and by the area which is in contact with an electric conductor. A bare wire carrying our ordinary lighting current at 110 volts or 220 volts pressure may be handled safely if the skin which the wire touches is *dry* or if the person's boots by which the current leaves are *dry*. But let the hand be wet with water or with perspiration or let the person stand on damp floor or ground, then enough current may pass through the heart to paralyze it, and death will occur suddenly. Most fatalities from industrial currents comes from those at 500 volts to 5000 volts pressure. People who have received shocks from a 10,000 volt current have lived.

At low voltages the alternate current is three to four times as dangerous as the direct current but at high voltages the direct current is the more dangerous. It is safe to pass a current at

several hundred thousand volts pressure through the body if there are over 10,000 alternations per second. Three-tenths of an ampere causes death at low rate of alternations but three amperes can safely be taken if the alternations are half a million per second. With wet hands and feet the resistance of the human body may be from 1000 to 1500 ohms. This is not much of a resistance for the lightning at its great pressure to overcome. A person standing isolated on moist soil makes an attractive target for the lightning. If taller objects of equally low resistance are nearby the person may escape or receive only a minor shock.

There is a superstition that "lightning figures", found on the skin of a person struck by lightning are mysterious photographic reproductions of trees, landscapes or objects in the neighborhood at the time the person was struck. But the various figures produced doubtless show the distribution of the high potential electricity in passing along a poor conductor and the consequent burning along a ramifying path.

If you are out of doors in a very severe electrical storm, it is well to observe the following rules for your own protection.

1. Keep away from wire fences. They may carry a dangerous electrical charge long distances. Cattle in pastures are frequently killed from the neglect of farmers to ground the wire of the fence.

2. Keep away from hedges, ponds, and streams.

3. Keep away from isolated trees. Oak trees are frequently struck; beech are seldom struck. It is safe in a dense forest.

4. Keep away from herds of cattle and crowds of people.

5. Do not hold an umbrella over you.

6. It is safer to sit or lie down in an open field than to stand.

7. Drivers should dismount and not stay close to their horses.

8. Do not work with any large metal tool or implement.

If you are indoors.

1. Keep away from the stove and chimney. The hot gases from the chimney may conduct the lightning to and down the chimney.

2. Do not take a position between two bodies of metal as the stove and water pipe, for example. An exception to being near metals is the case of an iron bed. One of the safest places is on a mattress in an iron bed, provided you do not touch the metal. The metal surrounding you makes a safe cage which will prevent the lightning from reaching a person inside.

3. Do not stand on a wet floor nor draw water from the well or faucet.
4. Do not stand directly under a chandelier, near a radiator, nor on a register.
5. Do not use the telephone.

The telephone instruments and users to a large extent are protected by use of a device—the *lightning arrester*. This consists of a ground wire coming close to the telephone wire but not quite touching it. The gap between is enough to prevent the current used in telephoning from passing across to the ground, but when the wire receives a high charge from lightning, the potential is so high that the charge easily jumps across the gap and passes to the ground instead of passing through the instrument and finding some other passage to the earth. You will observe that telephones properly installed in your homes are not placed where a person in using them could at the same time make contact with a register, radiator, or water pipe.

You are invited to send to the editor, an account of any experiment or demonstration which you have found useful in explaining any subject relating to lightning.

Some Experiences in Teaching General Science and Physiography¹

By HARRY A. RICHARDSON, Teacher of General Science and Physiography in the Woodward Avenue Junior High School, Kalamazoo, Michigan.

General Science was introduced into the Kalamazoo public schools a year ago last fall. We have it in both the seventh and eighth grades. In the seventh grade it is required of all pupils and comes two times a week; in the eighth it is an elective and comes four times a week.

We use the text book as a background and build up around it. And we are frank to confess that it takes some building as we have not yet tried out the book that exactly fits our conditions or meets our requirements. One reason for this, aside from the in-

¹ Abstract of paper delivered before the Michigan Schoolmaster's Club at Ann Arbor, in March, 1916.

trinsic faults of the books themselves, is because the conditions require material for two years of work, and that it be put in language within the capabilities of the pupils in the grades where the subject is taught.

We do not begin at the front of the book and take up each consecutive chapter in order, but select the ones in the book which we think most suitable for the grade of pupils with whom we use them.

There is no laboratory work in our course, the experiments being entirely demonstrational. We feel that the pupils are not mature enough to undertake such work, that the method for performing the experiment would monopolize all the thought at the expense of the truth to be illustrated. But without a doubt we shall outline some work to be performed by the laboratory method, such as, for example, the taking of measurements, the examination and testing of simple rocks and minerals.

But even now, in the performing of an experiment for demonstration, a pupil or group of pupils is sometimes called upon to give assistance or sometimes to perform the whole experiment. And in *all* discussions of the experiments performed, whether by the teacher alone or with the aid of some of the pupils the pronoun "we" is always used, and thus they are made to feel somewhat as though they themselves had done all the actual work.

There are those who think that it is necessary to have a great quantity of ready made and expensive apparatus for teaching general science, but my own experience does not bear out any such idea. By the exercise of a little ingenuity, and with the required materials, many a piece of apparatus can be fashioned, which in many ways is better than a more expensive, ready made one. For one thing it is liable to be simple, hence the principle to be illustrated is not apt to be obscured by the complexity of the apparatus. It also has a certain fascination about it. The pupils are almost sure to ask if the teacher made it himself and on being told that he did so, seem to take renewed interest and are impressed with the fact that the principle which the piece of apparatus illustrates, is not afar off and beyond the range of their own experience, but is very near to them. And many times a boy is willing, yes, anxious, to bring to school for the use of the class, some apparatus which he has made, or that has otherwise come into his possession.

Almost all our classes in the eighth grade and some of those in

the seventh, are required to keep a notebook in which a record is kept of each experiment, with regard to the purpose of the experiment, how it was performed, the results obtained, and the conclusions drawn. And it is gratifying indeed to see the results accomplished in some of these books. In our eighth grade, mechanical drawing is also an elective, and thus some of our science pupils have an opportunity, in making their drawings in their note books, to use the knowledge and practice of the mechanical drawing.

The work in the seventh grade deals largely with facts, although a number of principles are brought out and dealt with rather lightly. In the eighth grade more principles are studied the farther we go. This was well illustrated in a class last semester, in which class, for lack of sufficient advance material in our text book we early in the semester went back to review and spent about twice as much time on it as we did on going over this same material in the seventh grade.

Many times I have heard professors of science in high schools and others in normal schools and colleges, assert that the things taught in general science can be nothing but bare, simple, isolated facts, that the children of that age cannot grasp, remember or apply general principles. Some of those persons have had little or no experience in teaching science to pupils of that age. It would surprise some of those persons I am sure, to see the ability of pupils to grasp principles and do real logical reasoning concerning them. Of course it goes without saying that the principles must be given in a simple manner and entirely within the grasp of the pupil for whom intended.

Of late I have been reading with great pleasure and interest a recent book entitled "Methods of Teaching in High Schools" by Dean Parker of the School of Education, Chicago, in which he points out that children have long been thought by many people to be without the ability to reason, but experience shows such opinions to be false. It is true, he points out, that they make mistakes in their reasoning, but so do a great many grownups.

How pupils often possess the ability to make application of a fact or principle learned, was well illustrated in one of my seventh grade classes. The subject we were studying was water, and we had just brought out the fact that water dissolves gases, which are driven off on its being boiled, when one boy exclaimed, "Oh, now I understand." Then he told us how some days before, he

had emptied the water out of the globe containing the gold fish, and in his haste had refilled it with water from the tea kettle, which had cooled only shortly before, and on arriving home at noon, found that the fish had died.

In all topics studied we endeavor to make every day applications, to connect up with the out of school experience of the pupil. When studying a certain topic, pupils are often asked to search for relevant material from sources in their every day life, and it is truly wonderful to see what a wealth of contributions are made in this way.

For the first year or more, we seldom if ever say "This comes from chemistry, that from physics, the other from mineralogy." But in the latter part of the eighth grade, the question of the science from which the subject matter is taken, or what is the ground covered by a particular science is not uncommonly asked.

Wherever and whenever the opportunity offers itself, which is not so very frequent, we try to correlate the work with arithmetic, which we think is done with profit to both subjects.

It is our experience that seventh and eighth grade pupils are intensely interested in science and are able to make application of some of the principles learned. The work of general science has been the means of holding in school more than one boy who would have, for lack of interest, dropped out, or attended because compelled to do so. In this connection I might say that other boys have told me that the work in general science has awakened an interest within them, not only for this subject, but has caused them to care more about their other school work than before.

As to our methods of teaching physiography, they are not much different from those in common use elsewhere.

Although we have three junior high schools and one high school, which latter is comprised of all four high school grades, for the last two years the work in physiography has been limited to Central High School and Woodward Avenue Junior High School.

Our course, as in most places, is found in the ninth grade and covers one year of time. The text book employed is *Elements of Geography*, by Salisbury, Barrows & Tower. An attempt is not made to cover that entire book, but the greater part is gone over. Thinking that it better lends itself to the beginner in the subject, we take up materials of the land and their uses, and the development of the various land forms in the first half of the ninth

grade and the mathematical geography and climatic factors in the latter half.

The number of class recitations per week is four, with one laboratory period. The laboratory exercises are first worked out by the pupil on rough paper and are handed in for inspection, after which they are returned to the pupil for correction of errors. When these are properly made, he is directed to copy the whole exercise in its corrected form and hand in for grading.

Opportunity is occasionally offered for performing class room demonstrational experiments and whenever of sufficient import the pupils are required to write them up as a part of their exercises.

If the school program is so arranged to allow it, field trips are taken with the beginning class in physiography a few times during the semester, on which trips, different soil structure and formation, stream movement and action, different land forms and whatever is considered of relative interest to our subject, are pointed out.

As to my personal preference of general science or physiography, I have not any. But I do have definite ideas as to this question: "From which does the pupil at this age obtain the greater value; which one is better adapted for forming habits and ideals, which he will carry with him through life?" My answer is in favor of general science.

Superintendent Francis of Los Angeles at the Detroit meeting in February said that education does not consist in simply passing the "minimum essentials," but in living, in making the boy able to talk intelligently regarding the things about him; that the science of boys and girls in handling snakes and plants is almost equal to that of the laboratory expert.

With great significance, it seems to me, I hear the echo of this same thought coming from across the water. For in the November 18th number of "*Nature*" published in London, in the leading editorial entitled "*Science for All*," a plea is made for the schools to cease trying to make research experts out of the comparatively small number of pupils who have sufficient courage to elect the sciences; not to treat them in such an intense, abstract and forbidding manner, but to broaden them out and allow the average pupil to see some of the glories and beauties of the various sciences and better appreciate life about him.

Many times teachers and laymen have been heard to say, "This

taking of one fact or principle from one science, and another from some other and putting them together, I call a hodgepodge. Can that be called science?" The answer I take almost verbatim from Dean Parker's book, mentioned above: "If a student who is presented with a problem concerning ventilation, for example, has to search for relevant material from various sources he may be doing the highest grade of logical, reflective thinking. If he keeps his problem clearly in mind, if he searches for evidence in an unbiased manner, if he rejects irrelevant material, if he arranges and organizes his ideas, if he formulates and verifies his conclusions, he is being logical in the highest sense, he is being scientifically minded, he is acquiring skill in the use of scientific method, and he is on the right road to become a scientist.

And right there, to me, is one of the greatest values to be gained from the study of general science. Dr. Bagley has made the point that habits are transferred only when they become conscious ideals. And I firmly believe that this subject offers far greater possibility in this regard for pupils of the junior high school age than does the science of physiography. It provides a great possibility for a training in scientific method to the end that the pupil may appreciate the value of scientific knowledge in solving the problems of later life, and may use the scientific method in their solution. This is an ideal which I strive to hold before the pupils in my own classes."

Obstacles in the Path of General Science

FRANK M. GREENLAW, Rogers High School, Newport, R. I.

Few subjects added to the high school curriculum in recent years have attained such widespread popularity as *general science*. The pressure for courses of study which eliminate latin and algebra from the work of the first year of the high school and the increasing tendency to regard typewriting and stenography as better placed in the later years of commercial courses have created a demand for work which can profitably be given in the first or second year. Physical geography, commercial geography, biology have been tried but not generally accepted. Now comes general science; and administrators all over the country have hailed this as a convenient means of filling a program, a receptacle into which all pupils might be gathered who were not fitted for the

'higher things' of the traditional routine. Herein lies one of the chief dangers to the lasting success of the new movement.

Further, there is serious objection to the introduction of undifferentiated work in a school which is professedly higher than an elementary school. There is naturally wide difference of opinion on this point; but the strong tendency towards early differentiation of courses which has led to the establishment of junior high schools carries with it differentiation of subject matter in senior high schools. Where such separation of grades is accomplished, it appears that general science belongs to the lower rather than to the higher group of grades.

A third difficulty arises from the large number of pupils for whom provision has to be made and the lack of a broad equipment on the part of many teachers who are called upon to teach general science. It has been well said that this work demands the best teaching that the science department has to give. Perhaps no other subject is so well adapted, in proper hands, to arouse the self-activity of the pupil, to cultivate his initiative and resourcefulness. Few, if any, subjects lend themselves so readily and helpfully to social applications. The girl or boy of today who cannot run an automobile is almost an exception. Pupils often know much more about wireless than their science teachers. Here are basic attainment and interest which are duplicated in many fields. Even the 'movies' provide a starting point if attention is shifted to the projection apparatus or the cinema camera. And that teacher is wise who sets the heroes of modern science over against the lurid heroes of the screen. What I wish to suggest is that the work in general science, to be worth while, must start from and follow the science experience and interest of the pupil, that so far as possible the pupil should determine the direction of the work and share in responsibility for the success or failure of the result.

There will be some administrators who prefer the comfortable order of things in which the teacher assigns each day three or four pages of the text for tomorrow's recitation. Let us be charitable. Perhaps we too once followed the easiest way.

General Science Bulletin

*Preliminary Draft prepared by the Massachusetts State Committee
on General Science.¹*

PREFACE

General science is the outcome of a distinct movement to re-organize and readjust science instruction so as to meet the needs from twelve to sixteen years of age, in the two upper grades of the elementary school and the first year of the high school, or in the junior high school. The purpose of this instruction is to give a knowledge of physical environment, including earth formations and processes, the heavenly bodies, the atmosphere, weather and climate, various materials and their changes in substance, form and position, natural forces, and their use or control by man in such industries as agriculture, manufacturing and transportation.

The term general science, is commonly applied to several undertakings widely differing in content, organization and methods employed by teachers, in text-books, and in courses of study. Justification for the term general science may be had in that in all cases material is drawn from the entire field of nature, without regard to the artificial limits set up by the special sciences, such as chemistry, physics, biology, meteorology, and astronomy.

This term may also be regarded as including all the efforts which are actuated by a spirit of protest and reaction, not to say revolt against the extreme specialization in the teaching of science, particularly in the earlier years of the high school, which emphasized the mastery of subject matter and drill on formulas, rather than adaptation to the interests, capacities and limitations of the pupil.

There is also manifest a desire on the part of many high school teachers of science to secure large freedom in regard to both content of subject and method of instruction. Such freedom is impossible, when definite, uniform standards are imposed on

¹ This committee consists of William Orr, formerly Deputy Commissioner of Education, chairman; Howard C. Kelly, High School of Commerce, Springfield and W. G. Whitman, State Normal School, Salem. The report as here printed, is not in its finished or final form. Criticism and suggestion are invited by the committee.

high schools from some outside authority, either public or private, as by an examination system.

Doubtless this movement for a new type of science instruction owes its origin, in part, to dissatisfaction with results of existing modes of instruction on the part of both teachers and public. This dissatisfaction has been accentuated by the decline in the proportion of pupils in the science courses in the high schools. That in an era in which science was assuming such an increasingly important place in the thoughts of men and in the processes of industry, there should be a declining interest in the study of natural and physical phenomena by boys and girls in their teens was regarded as constituting ground for serious criticism.

There was also evidence at command to show that with all the elaborate equipment of high school laboratories, and provisions for instruction in the sciences, there prevails a very widespread ignorance among the public of the most elementary facts and processes in the world of nature.

As a result of these influences, many experiments are now being made to outline a more satisfactory procedure. Some of these enterprises are conducted with an imperfect understanding of the actual problems and conditions involved, and are likely to prove futile. In other cases, even though the instructor may not be wholly clear as to his aims, the conduct of class work has improved, and a finer interest on the part of the pupil has been secured because of the new spirit in the school.

The practices in organizing courses in general science are as yet endlessly varying. Thus, there is often an absolute dependence on text-books; there is often a failure to adequately define aims and purposes. The teacher is prone to revert to routine methods of topical presentation. In fact, there is grave danger, unless a definite statement is made of the aims, purposes and principles on which a course in general science should be based, that the present promising movement for a better teaching of science in the earlier years of the high school will fail to make progress because of a lack of definite direction, and that there will be a reaction toward traditional methods of instruction which, despite their shortcomings, were directed toward clearly defined ends and aims, even when these were not valid as regards the interests and needs of the pupil as an individual, and as a member of social and civic groups.

This Bulletin is intended to give a statement, in somewhat summary fashion, of the aims of a course in general science, and to define the place of such a course in the program of the formal schooling of boys and girls from twelve to sixteen years of age. The Bulletin also outlines the principles on which the selection and organization of material are to be based. Examples and illustrations are given as suggestions, and in no sense as parts of a syllabus.

The methods of conducting class work are outlined, and a statement made of desirable equipment.

A list of projects is presented, as suggestive. It is not intended that the Bulletin should in any way be looked upon as giving a definite outline for a systematic course of study.

INTRODUCTION

The term general science, as used in this Bulletin, denotes a course of instruction dealing with material drawn from the natural environment, for pupils of ages over twelve and under sixteen, particularly when such pupils are segregated in an intermediate or junior high school in which the teaching is done on the departmental plan. General science may or may not be a subject required of all pupils, although it is highly desirable that every boy and girl of the ages above given should have some opportunity for instruction in the phenomena of the natural world. A course in general science, however, should be open to all such pupils. Any pupil for whom work of this kind is decidedly undesirable should not be required to pursue the course.

General science should include a great variety of work with the view of interesting pupils of different aptitudes and interests. Many of the pupils who pursue general science will not complete their high school courses. Others will be able to take one or more special sciences, as physics, chemistry or biology. The following program is suggested for the sequence of science in a secondary school program of instruction:

General Science for pupils of ages twelve to sixteen.—Grades 7, 8, and 9.

Biology.—Grade 10.

Physics or Chemistry.—Grade 11.

Physical Geography, advanced Chemistry, advanced Biology, advanced Physics.—Grade 12.

In a small high school, it will not be possible to offer advanced courses. In the public schools, the pupil may be offered as an alternative for general science, work in a foreign language, in history, mathematics or manual training.

The material in a course in general science is drawn from natural phenomena and processes, without regard to their classification under the head of special science.

The following time allotment for general science is proposed: Five periods a week for a year, making for the full high school year two hundred separate exercises. Individual laboratory work is desirable, although not essential.

Text-books should be used for reference purposes, and not as outlines of courses. The teacher in each school should largely determine the content of the course and the order in which the different types of material are considered.

General experience goes to show that twenty pupils to a division constitute a number with which most satisfactory results can be secured.

AIMS OF GENERAL SCIENCE

General science constitutes an element of liberal education. Its function is to give an opportunity for the systematic expression of the spontaneous interests, native curiosity and inherent desire of the pupil which lead him to crave a knowledge of natural phenomena, including the properties of material substances, forces and processes, and particularly the uses man has made of natural forces, and his conquest of the physical universe, both as to discovery of its secrets, and control of its energy. The principal purpose of general science is cultural.

As a result of courses in natural science, the pupil should be able to read more intelligently and with greater interest, articles on science in magazines and periodicals, and scientific books of a popular character. He should read with a greater understanding much literature which abounds often in scientific allusion. Examples of such literature can be found in the writings of poets, as Tennyson.

Apart from these main aims of general science, certain by-products may be naturally expected which come under such aims as lie within the immediate field of physical, social and vocational education.

In some instances, the work in general science may have in mind aims that come under one of these three heads, but if so, this practice should be clearly in the mind of the teacher. Any attempt to seek to secure several aims at one time is likely to lead to confusion and poor instruction.

Thus, it may be possible in a course in general science to lead pupils to understand the importance of good food; of a supply of pure water. Their sense of civic responsibility may be developed by showing, through certain undertakings in general science, how scientific knowledge and method can be utilized in public sanitation and hygiene. Contact with various industries may give pupils some insight as to their capacity in different vocations, or certain parts of the course in general science may be used for this specific purpose.

The main purpose of the course, however, as stated above, is that the pupil may deepen and broaden his interest in natural phenomena. General science should promote a wide outlook upon the world of matter. The work should be so organized and conducted as to give large mental satisfaction, which comes from the gratification of real needs and desires. There should be an increased appreciation of the delights and satisfaction to be found in the study of nature.

In view of the above considerations, it would appear clear that the purpose of general science is not to give the pupil, in any sense, a mastery of a certain body of organized knowledge, or a command of formulae; nor is it intended to develop expert scientists, nor primarily to give training in scientific method. Rather, general science gives the largest possible opportunities for the exercise, along the line of the pupil's interests, of the inherent desire to know more of the universe in which one lives.

THE SCOPE OF GENERAL SCIENCE

General science draws the material for its courses from the entire physical and natural environment of the pupil, particularly, from that which is within the range of his immediate experience. The teacher of general science, however, is at liberty to direct the attention of the pupil beyond those objects and phenomena that come within his immediate environment. In selecting material for the course, the teacher should not recognize any of the formal divisions of human knowledge concerning nature, such as chemis-

try, physics, biology, meteorology, nor should the technical terms used in connection with these divisions be, as a rule, emphasized except as designating objects or classes of objects or forces.

Inasmuch as most teachers of science have gained their knowledge of the physical universe through instruction in the special sciences, it will not be altogether easy to adjust a viewpoint in which one deals with the natural environment, as a whole. It will be necessary to keep clearly in mind that the pupil is to be brought as directly as possible into touch with the objects and processes, and that nomenclature, formulae and technical terms should not be permitted to interfere with such direct observation and experience.

General science in its scope does not, moreover, undertake the mastery of the material that would come under some particular science; in fact, the term—mastery of science—as used in the schools is really a misnomer, as such an accomplishment by a pupil is practically impossible; moreover, it is doubtful whether the ability to hold in memory a certain amount of organized material does really constitute the mastery of a science.

Any subject or theme taken up in the work in general science should not be treated exhaustively. Many projects available for use in general science relate to processes and changes which in many of their aspects are beyond the comprehension of pupils, such as the explanation of why salt dissolves in water; why sap rises; the reason for the action of sulphuric acid on zinc containing carbon. On the other hand, it may well be possible for the child to apprehend immediate concrete action and processes, and the conditions determining such action, as the expansion of water on freezing; the effect of heat in hastening solution; the effect of moisture on the germination of seeds. It is well within the scope of general science to bring about an interpretation of those natural phenomena which come within the range of the experience of the pupil or in which pupils are already developing an interest. The material, however, should not be presented in a technical form, nor should large place be given to quantitative standards and calculations.

It is important that a pupil, when finishing a given subject in his course in natural science should be left with the impression that much is yet to be learned. It may be that in some instances the pupil is to be encouraged to pursue his researches even further,

but this method should rarely be followed in the case of the class as a whole.

General science should give information and added experience in all the fields of nature. In recent years, there has been much neglect of the study of those natural phenomena included under the head of astronomy, such as the heavenly bodies—their changes in position and appearance. The suggestion is made that the study of the sun, moon, planets and of the changing aspects of the heavens should be given a prominent place in general science.

It should be noted further that in dealing with problems in real life the student does not have any record of those artificial divisions by which special sciences are constituted.

It will be found that pupils, as a rule, are much less informed on natural phenomena than is generally understood. Many superstitious ideas remain, and there is a marked ignorance as to the most obvious of nature's teachings in common things.

Not enough attention is paid in teaching, as a rule, to showing how answers to questions and problems on nature can be secured from the dictionary, encyclopedias, and readable texts. Information on scientific matters should be made easily accessible to the pupil.

The teacher of science to boys and girls in their early teens should not limit the courses to a given number of subjects or experiments, or to statements of fundamental principles.

MATERIAL USED IN A COURSE IN GENERAL SCIENCE.

The subject matter of a course in general science, as above stated, is to be drawn from the natural and physical environment of the child. In whatever form this material is gained by the child, by reading or observation, by demonstration by the teacher, or by experiments of pupil or teacher, there should be established a very close connection with the concrete experience of the child. The following classes of material are presented as suggestions to the teacher in organizing the work of the class for a given year:

(a) Observation and study of phenomena of local character, including earth formations, minerals, rocks, trees, plants, crops, various household appliances and processes, weather observations, animal habits and seasonal changes. On the farm, one will find many machines and devices that will repay study.

(b) Demonstration by the teacher, including lectures and in-

formal talks, illustrated by experiments, lantern views, charts, diagrams and moving pictures and photographs.

Experience shows that a certain dramatic element can be introduced into such demonstrations. The effects in stimulating and arousing the interest of the pupils in the particular subjects under consideration are most satisfactory.

(c) Material gained by experiments made by the pupils in order to secure an answer to some particular problem which arises in connection with some phase of general science.

(d) Books dealing with science, such as natural histories, general descriptions of nature and scenery, text-books, popular and technical articles in magazines and newspapers, the Government reports, trade catalogues, particularly those containing descriptions of devices and machines, gazetteers, Board of Health reports and catalogues of firms manufacturing or selling motor boats, automobiles, gas engines, refrigerators, hot water heaters, hot air furnaces, and other productions in which one finds illustrations and applications of scientific principles.

Care should be taken in recommending reading for pupils not to call the attention to books and articles which are of an excessively technical character, as only few, if any pupils are likely to find interest in such work.

The reading of the pupil should be directed along some particular line, especially within the field of his own interests. There is danger, unless there be such direction, that the reading will become desultory and that little will be gained by the pupil in the way of information. Whenever pupils find material in their reading which makes an especial appeal to them and arouses their interest, they should be encouraged to bring such material of a scientific character to the class, and to present reports upon the same.

Note. The public service departments, such as those in charge of the water department, fire protection, health, good food, etc. will afford much material in the shape of talks and reports to be used in a course in general science.

While care should be taken in general science not to expect overmuch in the way of the mastery of generalizations by the pupil, occasions will often arise in which it will be possible out of very concrete cases to develop generalizations.

The teacher should undertake to find out in what undertakings

pupils of these ages are especially interested, and also their needs.

A number of type lessons should be organized, showing how material is handled under each one of the above heads. It is desirable that there should be a bibliography of reading material, and also a list of commercial appliances that are available for class study.

It must, however, be accepted that the test of the success of a course in general science is not found in the amount of material gathered by a pupil, nor in the statements committed to memory. If the interests of the pupils are broadened and deepened; if their range of study is widened; if more and more they bring material into the class; if there is an increasing disposition to report results in note-books, and to make reports; in other words, if there is a manifest gain in self-activity, then the teacher may accept the work as successful.

Note. In addition to the above material for reading, note should be made of the U. S. Government publications, such as those relating to National Parks; those should be selected which are in a readable form. The use of leaflets—each dealing with some particular phase—is also recommended. A school may gradually build up much material of this kind as the result of the work of individual pupils. Attention is called to the leaflets published by the Cambridge Botanical Supply Co., with such titles as: "How Soil is formed." "The Work of Plants," etc.

The material in a course in general science should be drawn from many fields. It will, as a rule, however, include facts and processes, inventions and machines which are of common interest in the life of the pupils. The material will be largely local. In some cases, the project will be suggested by some unusual local experience in the community or in the homes of the pupils, as: some insect plague, a great fire, a flood, a severe storm, the industries that predominate in any given community, as electrical appliances, paper-making, iron casting. Local natural phenomena may also be drawn upon for material, as: tidal wave or river action; or local enterprises calling for scientific knowledge, such as building a water supply. Temporary material may be either local, national or world-wide, suggested by some particular circumstances, as: a low water supply in a community would suggest the use of filters, and the various methods of purifying water; the use of poison gas in war; the sub-marine.

Apart from the knowledge of facts and processes, the pupil should, in a course in general science, gain a command of certain tools and devices, such as the use of measuring glasses, graduated, balances; of means of measuring, such as rulers.

Practice should be given in the systematic arrangement of data in tabular form, and also the use of co-ordinated paper, and the plotting of curves.

A by-product of no small importance is in the field of vocational guidance, as the pupil's attention is directed to various lines of activity wherein he may discover his bent.

(To be continued.)

General Science in the Junior High School at Rochester

HARRY A. CARPENTER, West High School, Rochester, N. Y.

PART I. ORGANIZATION AND AIMS.

The content of any well organized general science course must be determined by a careful consideration of the actual home, street, school and community environment of the pupils, together with the probable vocations or professions they may pursue. A general science course built around these needs will not merit the criticism of "a general science dominated by a specialist in any branch of science."

The general science course that does meet the above conditions will produce marked results as measured by training, information, hygiene and sanitation, and better health of pupils, only when conducted by teachers of the highest skill and tact; teachers who are willing and able to venture off the well trodden paths of the classic special science.

In developing the general science courses as we are now giving them in our first junior high school we have given much thought and study to the needs and aims of boys and girls as indicated by their home environment and working conditions, as suggested above.

As a successful general science course—no matter what year it is offered, must dove-tail with what ever science training precedes and comes after it. I will outline the plan that we are pursuing today. Let me take the opportunity at this time to

make clear that our work at Rochester is still in the experimental and formative stage.

The first year of actual presentation of the courses in the junior high school was preceded by regular Saturday Normal Class work for teachers throughout the year. At these meetings they attempted to anticipate and prepare. The past year of actual experience with the problem has reinforced some of our ideas and undermined other preconceived notions. The average grade teacher is wholly unfitted by science training, information and attitude to handle general science work effectively. They must therefore be given special help for the work and only the most efficient teachers should be used.

The general science teacher must love the work, must be buoyant and energetic. She must at the very outset gain the complete confidence of the children. She must be a science worker with them and yet a leader.

The population of the section of the city that contributes to the Washington Junior High School consists largely of various types of foreigners: Italian, Polish, German, Hungarians and few English.

The children from the sixth grade from seven contributing grammar schools enter the junior high school as the seventh grade and remain for three years—7th, 8th and 9th grades, the ninth grade being comparable to the 1st year of the regular high school. The senior high school consists of three years—10th, 11th and 12th.

The children presenting themselves for admittance to the junior high school show all the potentialities one would expect knowing their environment. A few are unusually bright and alert, some give evidences only of a passing interest in things educative, while a majority perhaps are rich with family tradition and superstition.

The pseudo-science work of the grammar schools consists of the usual physiology and hygiene; geography as it touches physiographical, astronomical and meteorological features; together with some nature study in a few instances. The content of the nature study work depends largely upon the personal interests and ability of individual teachers centering about birds—insects—trees—flowers, etc. In general the tendency of the teaching is toward information of science topics, rather than training in scientific methods and attitude.

In the Washington Junior High School, all entering pupils—7B

are given work in elementary science two days a week for 90 min. each day. The content of this and succeeding courses will be discussed under separate heads.

Before leaving the 7B grades the pupils must choose between the academic course for both boys and girls, and household arts course for girls and industrial arts course for boys. This choice is made only after a thorough study of the individual case and thorough co-operation of principal, teacher and parent. It is important to state however, that misfits in the 8th and 9th grades are transferred as the need arises.

The content and character of the science work for the 7A—8th and 9th grades is directly influenced by the needs of the particular department concerned, but the underlying aims and methods are the same. The academic pupils continue the elementary science in 7A as started in 7B grades. For these pupils the science work in 8B and 8A is limited to hygiene organized as a part of their regular physical training.

In the 9th grade the commercial and academic pupils are given general science three days each week for the entire school year. Each day's period for this science instruction is 90 minutes long.

In the industrial arts department, the boys are given general science one day each week for 90 minutes in the 7A and 8th and 9th grades. In addition to this, 30 minutes of physical training time is devoted once a week to science of hygiene and sanitation.

The household arts girls receive science instruction for two periods of 90 minutes each, every week during the 7A and 8th and 9th grades. This work continues the work started in the 7B but is shaped to serve the needs of the household arts girl more particularly. We believe that this science training is of genuine importance to these future home makers.

In order to show in a general way our plan of attack in all the science work I give below a few suggestions relating to the 7B work given to all entering pupils.

We are attempting to give these pupils the beginning of a training in science methods, thought and procedure—a training that will be of distinct service to each one no matter what road through life they take.

We select as vehicles for this training such topics as will furnish useful and practical information without regard for the particular special science of which it is a part.

The contents of all courses for the 7B and 7A classes are arranged in groups, and the order of the groups is dependent to some extent upon the seasons. While these groups are not necessarily inter-dependent, yet the information and training obtained by study of one group is made to play a definite part of the attack, by the pupil, of a succeeding group. Each group is composed of a few closely related and inter-dependent topics.

In the presentation of any topic for example, Rocks, care is taken not to introduce any subject matter that is beyond the mental grasp of the pupil just because it happens to be of technical significance. Technical terms and classifications are omitted unless they can be clearly presented to, and comprehended by the pupils.

The first group of topics for the early fall in the 7B sections includes rocks, soil and rivers. We do not have the children study rocks, for example, from the mineralogical standpoint, nor the geological classification but we do want these boys and girls to know whether they are looking at or handling a lime-stone or a sand-stone, etc. We want them to know the commercial sources of these building stones. We want them to be aware of their building uses, and the relation of characteristics and use, or in other words we want these children to know ordinary building stones from an every day practical standpoint.

We endeavor to see to it that they get this information in such a manner as to give them training in observation and scientific methods of attack. All study of these topics is as far as possible preceded by out-door or laboratory observational work, sometimes by the individual alone and sometimes in class groups supervised by the teacher. All material collected and brought in by pupils must have its written "story" giving all information concerning it, and this information must be organized.

In all the science work the study, as well as the laboratory work is under the direct observation and supervision of the teacher, and it is possible therefore, to obtain more satisfactory results than after the older plan of allowing the student to study by himself. The idea is well expressed by the note received by a teacher from a care-taking parent, "You teach John his geography and I will hear him say his lesson." The fact is, we teachers spend too much time "hearing lessons" and not enough time teaching boys and girls. It is of prime importance to teach them how to study.

The 90 minute period makes this method possible and much skill is needed to properly balance, study, discussion, demonstration and laboratory work.

Following the group of topics mentioned above is a group of topics including the study of Air and Fire, and in these topics the elementary notions of combustion and combustibles is given. These facts however, are not taught from the standpoint of specialized chemistry, but from the direct view point of the boys and girls experience. We take the experiences which they have, and add other experiences by means of laboratory and observational work. We correct their wrong ideas and put in their stead accurate scientific knowledge covering the topic. Topics of this sort lend themselves readily to health and sanitation applications; the study of fire risks and fire control. Here too is an opportunity to instill in the pupil a conception that he has a duty to himself and others not to be careless since personal carelessness is the big cause of disease, accidents and fires.

In all the science work the pupil is made to believe that he is an important part of the whole civic unit and that each must do his full share in civic betterment.

One noticeable feature in the usual science scheme of today is the lack of opportunity and incentive for a pupil who shows unusual interest or ability in a special field, to continue the study of that subject without interruption, and at the same time without undue encroachment of the time he should devote to other fields of study.

For example, a boy or girl may early in their science study exhibit unusual activity of thought initiated by elementary study of the stars and planets. In fact I have in mind two 7B boys especially, who have shown remarkable aptness for things astronomical. I ask, what provision is made by a science plan for boys of this sort to continue the study of this, their hobby? All boys and girls show a liking and ability for some one thing.

What happens in most cases is what I have been forced to say many times in the past. "Yes, yes David, I am glad you like astronomy, and I advise you to read books and when you get to college (if he ever does) you can study more astronomy." What does David do? Just what all the others do, drifts through other interests, farther and farther away from his first real interest and may be a great astronomer is lost to the world.

Just so far as our science teaching makes no provision for the exceptional pupil to pursue the study of a particular interest, to pursue a hobby if you will, just so far does our teaching fail.

How can this provision be made? We are trying to solve this problem in Rochester through the medium of carefully worked out Science Bureaus or club sections. This is of course entirely voluntary work on the part of the pupil, but is under the direct supervision of a trained teacher. Through these Science Bureaus we hope to stimulate the formation of a hobby, to give an opportunity for David to continue his study of astronomy along with other boys and girls in the same line. In this way the ordinary gaps in the pupil's astronomical interest will be filled, and he will continue to climb his chosen hill.

In this age of specialization to use the wise words of one of my college professors, "We must know something about everything and everything about something". We must have our pupils get about this "knowing" early.

I feel that the full measure of success of any general science work in the grades or high school will be obtained only when that general science work is supplemented by the carefully organized club plan which will furnish the stepping stones across the streams of other important activities, and allow the boy or girl to give uninterrupted and directed attention to a special interest.

The laboratory part of science work in the past has shown an interesting growth and variation. Originally all laboratory work was of the nature of teacher's demonstrations, and was calculated to inspire awe on the part of the pupil for what appeared to be the skill and magic of the teacher; or the demonstration took the form of delightful entertainment. Later much of the laboratory work of the science was performed by the pupil. He was set the task of "discovering" this or that law or relation already known to him. Still again the wave changed and the work was dominated by a demand for skill in the use of refined instruments of measurement and the application of much mathematics.

In biological laboratory work accurate drawings of microscopic objects was required, while at the same time the pupil could not make a drawing of a fish that could be recognized.

Almost any kind of laboratory work came to be the scheme of things so long as it was "individual" and "trained" for accuracy. Whether the pupil grew mentally as a result did not matter

if only his note book was neat and orderly. The laboratory work has not produced results commensurate with the time and effort spent thereon.

It is possible that too much individual laboratory and not enough group work has been given. Certain it is that with seventh grade pupils the "individual experiment" is for the most part a failure. Those young minds lack the control and attitude that is required to make an individual laboratory experiment worth while. They must work in groups under the immediate direction of the teacher or the work should be done by the teacher with the pupil looking on. It is true that there are certain experiments that may profitably be done and should be done by the pupil, but great care should be exercised if profit is to accrue to the pupils advantage. A teacher's demonstration is excusable only, if it teaches and drives home an important fact and the experiment must serve as an example to the pupil in science method, science integrity to facts and conclusions. No demonstration should be presented without first deciding just what it is expected to do for the pupil from every standpoint.

A feature of our work is what may be called our Observation Bulletin. In all classes and at all times of the year the attention of all pupils is directed toward definite seasonal observations and they are required to make careful and accurate notes. In this way, in the seventh grade for example, the pupils get a certain familiarity with the circle of events in the life history of plants, insects, birds, seasonal changes, etc., all of which can be studied later to better advantage because of these familiar experiences than otherwise. These experiences form the basis of later science study.

In all the elementary and general science courses a fair balance between biological sciences on the one hand and physical and geographical science on the other is maintained although the work is not separated into the special sciences. The pupil's work is definitely mapped out for him, and concentrated, productive, effort is required at all times.

In the 9th year for academic and commercial pupils, biological science, as interpreting the health and hygienic needs and habits of adolescence, civic sanitation and man's environment, forms the key note. Frank use is made of helpful parts of all the special sciences, although the course is not at all divided by lines that mark off the usual boundaries of the special sciences.

The attempt is made to:

- 1st. Supply important and usable experiences.
- 2nd. Make a word study of all new words.
- 3rd. Give the pupil simple, accurate concepts.
- 4th. Require adherence to scientific accuracy.
- 5th. Have the pupils apply experiences and concepts already acquired, to the solving of new problems.
- 6th. Form habits of scientific study and methods.
- 7th. Develop powers of observation and awareness of surroundings.
- 8th. To train pupils to think.

The methods used include supervised study, laboratory work, demonstration, recitation and excursion, Science Bureaus for special study and Observational Bulletin activity.

The topics for study are arranged in groups and the information and training obtained by study of any group is made to play a definite part in the study of succeeding groups. The arrangement of groups is somewhat determined by seasonal changes. The arrangement of topics within a group is either psychological or logical as the particular case demands.

Why Science in the Grades

PERCY E. ROWELL, Director of Science, A-to-Zed School,
Berkeley, California.

There is no doubt but that the curriculum of the grades is crowded beyond all endurance, and still the advocates of other subjects are constantly urging their introduction. Moreover, these new studies are just as desirable as many of those which are already being taught, sometimes, in fact, they are more deserving of a place in the curriculum than are some of those now present. The solution of the difficulties which are presented by this continual increase in the number of courses which are given in the grades, is one which interests, as well as stimulates all educators who realize that the mind of the pupil is shaped in the elementary school.

This accumulated mass of courses in the curriculum is rendered still more unbearable because so many of the studies not only bear little relation to one another, but even are to a great

extent disconnected from life's problems. If there could be centers of interest, around which the studies might be grouped, the result would be a greatly reduced congestion in the course of study, and on the part of the pupil, a much clearer understanding of the true meaning of his work. The pupils are busy all day long, and there can be but just so much work; the question resolves itself into one of management, of clear-cut discrimination, and of courage to undertake new plans. The demand is for greater efficiency.

This disconnectedness of studies from the problems of everyday life is well illustrated by the usual course in arithmetic. As a rule, when a pupil is in the arithmetic class, his mind and attention are concerned with arithmetic, as such. The rules and problems follow one another with a smoothness which is dangerous on account of its lulling effect upon the minds not accustomed to the subtleties of mathematical reasoning. Following the rule, the problem is easy; away from the guide, the example has a strange and foreign look. That is, such arithmetic is bookish, is cultural perhaps, but the examples are not true problems; they merely illustrate the preceding rule. Sometimes, it is true, the vocabulary of daily life is used; we are encouraged with the hope of better work only to find that while the names of the units have been changed, the "problems" are the same.

When a search is made for some co-ordinating principle, or some satisfactory means by which the various disconnected studies may be brought into at least a family gathering, it is almost forced upon the investigator that this determining guide must be the life of the pupil. This does not mean the life of any individual, but rather the composite life of all the pupils. The life of the pupil is the pupil, and his life is concerned with those factors which contribute to the satisfaction of his needs and the fulfilment of his desires. Whatever such a course, or rather such a backbone for all the courses shall be named, is immaterial; but, since it should be both exact and fundamental, it had best be called science.

A science course for this purpose should be based upon the real necessities of the child. A little thought will lead us to realize that these needs are Light, Heat, Air, Water, and Food. A study of food leads to a consideration of the sources of food, namely, plants and animals. In addition to these absolute needs,

modern life has trained our desires to require the comforts and conveniences of civilization. To appreciate the latter more fully, requires some study of Mechanics, Magnetism, Electricity, and the Arts and Industries. No one branch of science can do this, nor can science be properly taught in the grades without doing it. A blending of all the sciences, as a means for best teaching, is inevitable.

Such a course would mean much to every pupil. He would realize, to an extent never before possible, the value of remaining in school. When we consider that forty per cent. of the reasons for leaving school are within the school itself, we should pause and question whether it would not pay to teach the child from his viewpoint. Educators have been urging a certain sequence of studies because that particular order is scientifically correct, but the pupils have calmly gone their own way, which is out of school. When only twenty-five per cent. of the pupils continue on into high school, surely the school has failed to supply their needs. The pupils are the educator's public; if they are to be elevated they must first be reached. In the beginning the public must be given what it wants; later it may be given what it should have. The first problem is to hold the public.

The child is not aware of its needs, but it knows that it is doing much useless work when example after example is done at the command of some teacher. Show that child that he can use his arithmetic in some practical manner and he will gladly perform a formerly irksome task. Science, more than any other course, can supply incentives for arithmetic, drawing, reading, writing, oral and written expression and, best of all, real and creative thinking.

An Optical Illusion Makes The Moon Seem Larger When Near the Horizon

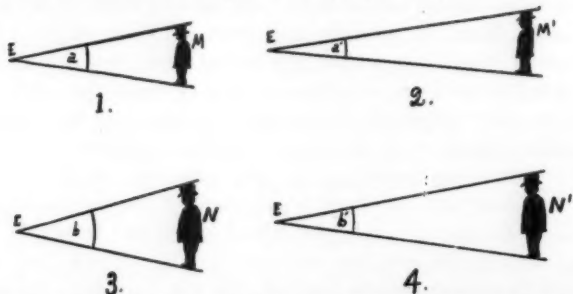
RETLAW MATHWIN.

In order to understand why the moon near the horizon, whether rising or setting, appears much larger than it does high in the sky, one must consider two things. First the angle of vision and second the unreliability of one's estimate of distances under certain conditions.

As a matter of experience in judging the size of a distant body,

we unconsciously and involuntarily consider the angle of vision and the distance to the object, then we form our judgment regarding its size.

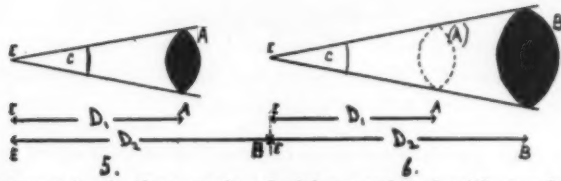
When we see a man nearby, the angle of vision is large (Fig. 1., angle a), but if the same man is at a distance the angle of vision is small (Fig. 2., angle a'). Unconsciously we consider distance and angle of vision together and give our judgment that the height of M' is the same as the height of M . (Fig. 1 & 2).



Figures 1-4. With the same object at different distances, the nearer the object, the greater the visual angle. With different sized objects at the same distance, the larger the object the greater the visual angle.

If a taller object N is at the same distance as M it will form a larger angle of vision (b , Fig. 3) and it will therefore appear larger than M . An object, N' , the same size as N , but at a greater distance will be in our judgment of the same size at N , for the same reason that our judgment tells us that M and M' are the same size. N' would appear larger than M' because it is the same distance from the eye but produces a larger angle of vision. (b' is larger than a'). The angle of vision in Fig. 4 may be smaller than that in Fig. 1 and yet we judge N' is larger than M because of its greater distance.

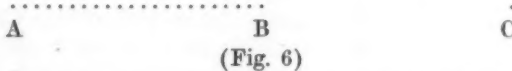
If for any reason we are deceived in our judgment of the distance, the angle of vision and the misjudged distance will produce an error in our judgment of the size of the body. For example, if an object (Fig. 5) is situated at A , a certain distance (D^1) from the eye, but we have misjudged the distance and consider it farther away, say at B , (D^2) then we interpret the size of the body by using the angle of vision actually produced by the body at A (c) and the distance to B . But an object at B to produce the same angle of vision as that produced by the body at A must be larger



Figures 5-6. A given angle of vision combined with a misjudged distance gives us a false judgment about the size of an object.

than A and consequently the object A appears to us larger than it really is. Thus are we deceived into thinking a body is larger when we are led to believe it is farther away than it really is.

In order to show how fallible one is in estimating distances, hold Figure 6 in front of different people, first covering the reading matter above and below it with white blank paper.



Ask which is the longer distance AB or BC. Nearly all will say that AB is longer. Measure the distances and you will find that they are exactly the same. The presence of a number of objects in the intervening space in some manner not well understood, causes the optical illusion.

When the moon is seen near the horizon, various objects on the earth's surface are visible and these objects in the intervening space make the distance seem greater than it is when the moon is so high in the sky that few or no other objects are visible along the line to the moon. You can further prove that it is the sight of objects along the path of vision that causes the optical illusion, by shutting them out of your sight when you look at the moon which is near the horizon. Roll a sheet of paper into a tube about one foot long, close one eye and look at the moon through this tube with the other eye. The paper effectually cuts off the vision of the objects on the earth's surface and the moon appears about as it does high in the sky. To get the effect of seeing these objects and the moon together remove the paper tube. Immediately the moon appears to increase in size.

If it were not for this optical illusion regarding distance, the moon ought to appear larger at the zenith because it is about 4000 miles nearer the observer. This greater nearness would make its apparent size increase about one-sixtieth.

Editorials

GENERAL SCIENCE AT THE NATIONAL EDUCATION ASSOCIATION IN NEW YORK.

The four special sessions on four different days were devoted respectively to chemistry, physics, biology, and science. One paper at least on general science was on the program for each of these sessions and many other subjects sidetracked into general science. The prominence of this subject in appearing on these different programs is significant and yet gives little idea of the keen interest given to it. In the last three sessions, nine-tenths of the discussion provoked was on the subject of general science. General science was the one live issue which interested all teachers alike.

At the physics meeting a group of text book authors discoursed on the bearing of general science on later courses in physics and chemistry. The general feeling was that the general science should be taught, not to prepare for some future course, but to develop and educate the pupil according to his capacity.

At the meeting of biology teachers, the biology committee reported through Mr. Eddy of the New York High School of Commerce, their plan for a two years course of required science. This was advocated to replace the one year of general science so widely adopted. This report was vigorously assailed by a number of speakers, the chief objection to it being that it did not remove the "vertical stratification" into special sciences which must be done to make science *general*.

At the final science session, Prof. Dewey gave us a masterpiece on "Method in Science Teaching", in which general science was the main theme. Enthusiasm for general science passed all bounds at this session until Prof. Fall of Albion College advocated general science for the grades, for the junior high school, and for the senior high school. Rather strong opposition to the extension of general science into the senior high school developed.

A pleasant and profitable feature of the New York meetings was the "get-together" dinners held at the Hotel Holley. Discussions of the day meetings were continued here; new friendships were formed, and some pleasant bantering was indulged in.

The excursions planned to industrial plants, commercial labo-

ratories and educational institutions were of much value to visitors. The science committee deserves much credit for arranging an unusually full, valuable and interesting program for the visiting teachers.

ORGANIZE A GENERAL SCIENCE CLUB

One who scans the programs of the various science teachers' associations for the past year is struck by the fact that unusual attention has been given to general science and that in some cases, more attention has been given to general science than to the special science for which the association was organized. There is but one conclusion to be drawn from this evidence, namely; that the science questions which are receiving the best thought of all our science teachers to-day are those of general science.

If we search out general science teachers and learn in which branch of science they consider themselves best fitted to teach, we shall find that some are botanists, some physicists, some chemists, some zoologists, some geographers, and some astronomers. These teachers know the best things in their own field and some of the things in other fields. It is usually more difficult for one to teach as well outside his chosen special field. Thus, we find that one general science course lays the emphasis on chemistry, another on botany, another on physiology, another on physiography, etc. To be sure there may be some advantages in having that subject taught which the teacher can do best; but at the same time some very valuable matter which is of vital interest to the pupil, is bound to be sacrificed. Moreover there is likely to be a narrowing of vision where breadth of vision is sought. Many times the general science course will be found to improve as the *teacher's view is broadened*.

The desired breadth of view does not come from a discussion of general science by chemistry teachers alone; it does not come from physics teachers, nor from biology teachers. When teachers from the various special fields meet in joint session and forget as much as possible they are specialists and when they make an honest endeavor to *learn* something from their fellow teachers in other fields of science, rather than each one trying to convince the others that he has the only thing worth teaching, then and not until then will there be much improvement in our

general science teaching. This is as true of method as of content.

The greatest need of science teachers at the present time is a forum, a club, an association—call it what you will—where science teachers representing different departments of science may meet, expound, discuss, deliberate and learn. There ought to be an organization in each of many local centers whose business it is to consider the pressing questions, the live questions in *general science*. Some state science teachers' associations have already established a *General Science Section*. This is a move in the right direction, but a small local club, meeting several times a year, would be of even greater value. The *Quarterly* will be glad to hear of any clubs or sections which are organized.

JUNIOR HIGH SCHOOLS ARE OFFERING GENERAL SCIENCE COURSES.

General Science is elective in the ninth grade of the junior high school in Adrian, Mich. Two hundred and twenty five minutes are given to it per week. The department is well equipped with apparatus for demonstration and experimental work. The second year of the course was marked by a 20% increase in the number of students taking the course.

Under the direction of the Edward Little High School of Auburn, Maine, is a two year junior high and a three year senior high school. In the first year of the junior high school, general science is a required subject two periods a week. In the second year general science is required three or five periods per week of pupils in the General Course and three periods per week of pupils in the Commercial Course. College preparatory pupils do not take general science in second year of the junior high.

Chelsea, Wakefield, and Wellesley, Massachusetts are introducing general science into their elementary or junior high schools this year.

Providence, R. I. has introduced general science into the seventh and eighth grades.

In the Washington Junior High School of Rochester, N. Y., two 90-minute periods are given per week to general science in the seventh grade. In the eighth grade general science is offered only to pupils in industrial and domestic science courses. General science is a required subject for all pupils in the ninth grade.

In Gary, Indiana, elementary science along the lines of special science has been carried on for several years in grades five to nine.

GENEROUS SOULED SCIENCE TEACHERS

It is encouraging to see what a large per cent. of the science teachers are willing, even eager, to help along a new enterprise which is attempting to fill a real and long felt need. The reception of the *General Science Quarterly* idea in advance of the actual appearance of the journal itself has been most gratifying.

If you do not find the kind of help you wish in the pages of this journal during the year, please write to the editor, suggesting the things which you would find most helpful in your work.

While the pages of this journal are open to the discussion of theories of teaching general science, the main purpose is to set forth the *best practice* in teaching it. It is often very difficult to apply theories of teaching under actual working conditions. Occasionally some teacher makes a successful application, or by accident stumbles upon a very successful lesson or series of lessons. If he be a generous souled teacher, as most science teachers are, he will share his "discovery" with his fellow teachers. You are invited to contribute an account of some of your successful methods, lessons, etc., and in return to profit by similar contributions made by others.

FREE SCIENCE BOOKLETS AND PERIODICALS.

In addition to the books in the hands of pupils and numerous reference books in the library, much valuable help may be obtained from various commercial booklets and periodicals.

The Lighting Handbook is a booklet of some ninety pages and contains much that is suggestive and useful to high school science teachers. It will be sent free to science teachers on application to Ivanhoe-Regent Works of General Electric Company, Cleveland, O.

Helpful Hints to Housewives, a sixteen page booklet giving directions for using the *Domestic Science Fireless Cookstove*, contains valuable information for general science and domestic science teachers. A folder *Tococo Talks*, Vol. 5, printed by the same company has interesting material in it. These will be sent free upon application to the Toledo Cooker Co., Toledo, Ohio.

Household Physics, No. 21 of the journal *Teaching*. This excellent number has articles on physics in the household, qualifications of high school science teachers, home made apparatus, etc.

28 pages. It will be sent free. Apply to *Editor of Teaching*, State Normal School, Emporia, Kansas.

Kodakery, a beautiful illustrated monthly magazine, contains many articles which are excellent for science lessons. It is a great help to anyone who is interested in photography. The magazine is listed at \$.50 a year, but teachers who desire to make use of it in science classes can secure it free of charge. Apply to Eastman Kodak Company, Rochester, N. Y.

Du Pont Magazine. Anyone interested in the use of explosives in peaceful pursuits will find some suggestive and useful information and pictures in this monthly magazine. Apply to E. I. de Pont de Nemours & Company, Wilmington, Del. This same company publishes *Vertical Farming*, a monthly journal of special interest to agricultural schools.

GENERAL SCIENCE CLUB OF NEW ENGLAND

During the school year 1915-16 two General Science Conferences were held at the Normal School, Salem, Massachusetts. These were attended by teachers from five different states.

At the first conference the discussion of the high school problems was led by Prof. Woodhull of Teachers College, Prof. Mann of Carnegie Foundation, and Mr. Orr, Deputy Commissioner of Education. Messrs. Vinal, von Hofe, Jr., Moore and Aldrich gave five minute papers. So animated was the discussion that it was voted to continue it at an afternoon session.

At the second conference, Prof. Kilpatrick of Teachers College gave an address on *Project Teaching* and Mr. Sherman and Mr. Lunt of Boston gave practical talks on general science in the elementary school.

As an outcome of these meetings, General Science Club of New England was organized with some thirty-seven charter members. The club draws its membership from the elementary school, the high school and the college, and will attempt to blend these different viewpoints. Dr. Dewey has said, "I do not believe that the problem of successful science will be met until teachers in college and high school exchange experience with those in the elementary school, and all take a mutual interest in one another's work." In some measure this club hopes to help do what Dr. Dewey suggests is needed.

(Continued on page 64.)



TO THINK and to KNOW HOW TO THINK

are two entirely different things, and there is nothing comparable to a good science course to

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This is one prime reason why the general science course, adapted as it is to immature minds, has met with nation-wide approval. Just as it fills a definite need in the school curriculum, so does

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The membership fee is one dollar per year, and anyone interested in general science is eligible to membership. *General Science Quarterly* is the official organ of the club.

General Science Quarterly and membership in the club may both be secured by special arrangement for one dollar and a half a year.

The following officers were elected for one year:

President, Mr. Walter G. Whitman, State Normal School, Salem.

Vice-President, Mr. Samuel F. Tower, English High School, Boston.

Secretary, Mr. George C. Francis, Centre School, Everett.

Treasurer, Mr. Arthur H. Berry, Classical High School, Providence, R. I.

Three members of the *Executive Committee*.

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